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A u.h.f. log-periodic receiving aerial

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RESEARCH DEPARTMENT

A U.H.F. LOG-PERIODIC RECEIVING AERIAL

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(RA-41)

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SUMMARY

A design of log-periodic u.h.f. receiving aerial has been produced which has substantially constant performance throughout Bands IV and V. The relative levels of side and back lobes do not exceed −24 dB in any channel and the gain is approximately 9 dB (relative to a dipole). Ease of manufacture has been considered as an important feature of the design. This type of aerial is particularly suitable for domestic reception in areas where gain is not the prime consideration but where delayed reflections from buildings, hills etc. are prevalent.

1. INTRODUCTION

It is obviously desirable that viewers should always use the type of television receiving aerial which gives the best results for their location. This usually implies the installation of an outdoor or loft aerial connected to the set with good quality coaxial feeder. The available field strength of the transmissions is only one of the factors which influences the type of aerial required. It must also be capable of discriminating against unwanted co-channel signals and delayed reflections over as wide an arc as possible. In some areas, the discrimination against delayed reflections is the most critical requirement. Receiving aerials as supplied by manufacturers can be obtained with adequate gain and their directivity is normally adequate to give protection against co-channel interference. Delayed reflections, however, need greater suppression in general if ghost images are not to be visible on the received television picture. Directional receiving aerials of the yagi type, which are the most common, tend to have side and back lobes in their horizontal radiation patterns which vary considerably with frequency and therefore differ from channel to channel. At locations where delayed reflections are potentially troublesome it may be impossible to position a yagi aerial to give sufficient protection against ghosts on all the available channels. The log-periodic aerial, on the other hand, although its gain is somewhat lower than a yagi of comparable size, can be designed to have a horizontal radiation pattern with extremely small back and side lobes which remains constant over a wide frequency band. It therefore appears to be especially suitable for areas of reasonable signal strength where delayed reflections are a particular problem. The design of a log-periodic aerial for u.h.f. television reception is described in the report. Particular attention was given to achieving a simple construction for ease of manufacture without sacrificing performance.

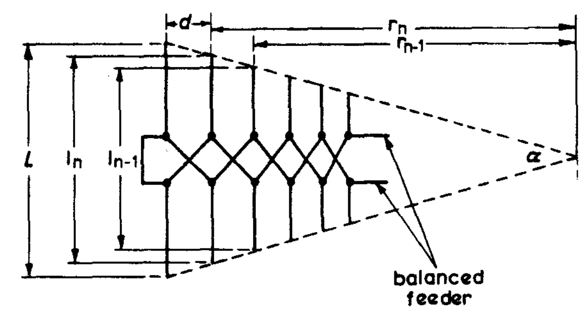

Fig. 1 - Schematic representation of dipole elements connected to balanced feeder, and illustration of design parameters T and σ

$$T = \frac{l_{n-1}}{l_n} = \frac{r_{n-1}}{r_n};\quad \sigma = \frac{d}{2L} = \frac{r_n - r_{n-1}}{2l_n};\quad \tan\frac{\alpha}{2} = \frac{1-T}{4\sigma}$$

$L = \lambda/2$ at the lowest frequency

2. DESIGN OF THE AERIAL

The log-periodic aerial design was based on data given by Carrel.[1] Adequate information on radiation patterns was not available, however, and therefore, measurements were carried out on a number of available log-periodic aerials. The results indicated that, a radiation pattern with low side and back lobe levels would be obtained for parametric values T = 0·93 and σ = 0·17. The meaning of the parameters T and σ is illustrated in Fig. 1. Calculation showed that these values of T and σ would give a gain of approximately 9·0 dB relative to a dipole. The design bandwidth was made 2:1, which is slightly in excess of that occupied by Channels 21 to 68 inclusive. This gave some latitude for possible deterioration of the aerial performance at both ends of the working range. The number of elements required to obtain this bandwidth was fifteen. In operation the log-periodic aerial has an

active region, determined by frequency, involving a group of dipole elements whose lengths are near to $\lambda/2$. All elements in the practical aerial were to be made from rod of constant cross-section and consequently it was necessary to make some allowance for the effective lengths of elements due to the variation of the ratio H/a, (H is the element half length and a its radius).

In this type of log-periodic aerial, all the dipole elements are connected to a balanced line; adjacent elements being connected in an alternate manner as shown in Fig. 1. (The practical realization of alternating connections can be seen in Fig. 2). The drive point of the balanced line is at the high frequency end of the aerial, the other end being terminated in a short circuit behind the longest element. The impedance characteristic is optimized by adding some shunt susceptance to the terminals of the transmission line.

3. MECHANICAL CONSTRUCTION

The balanced line on the axis of the aerial is made from a pair of 12·7 mm (0·5 in.) square cross-section, light-aluminium alloy tubes separated by 9 mm (0·354 in.) between adjacent faces. The elements are made from 6·35 mm (¼ in.) diameter aluminium alloy rod. The element limbs are rivetted to the balanced line conductors.

The aerial output is by way of an unbalanced feeder of 71 Ω characteristic impedance, carried through the centre of one of the balanced line conductors to terminals at the drive point of the balanced line. The terminals are protected by a plastic moulding. Mechanical support for the aerial is provided by a bracket mounted on the balanced line behind the longest dipole element, which also acts as the terminating short circuit. The arrangement of coaxial feeder, balanced lines and short circuit termination acts in a similar way to a Pawsey stub balun. The detailed dimensions of the aerial are given in Fig. 2. Fig. 3 shows the aerial with its normal mount which is suitable for either horizontal or vertical polarization. The type of mount shown in Fig. 4 is only suitable for horizontal polarization. The weight of the aerial, without clamps, is 1·02 kgm (2·25 lbs).

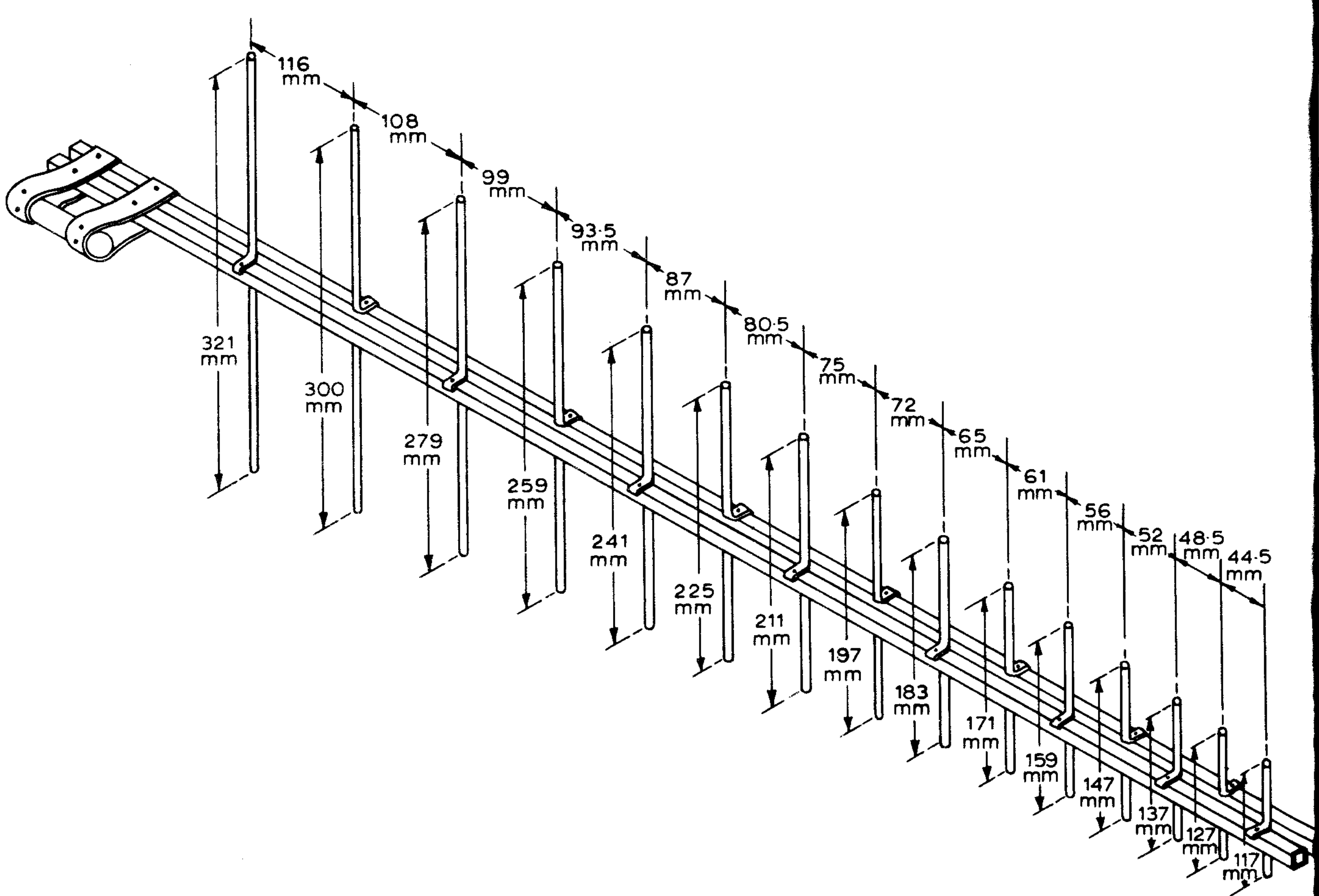

Fig. 2 - Construction and dimensions of log-periodic aerial

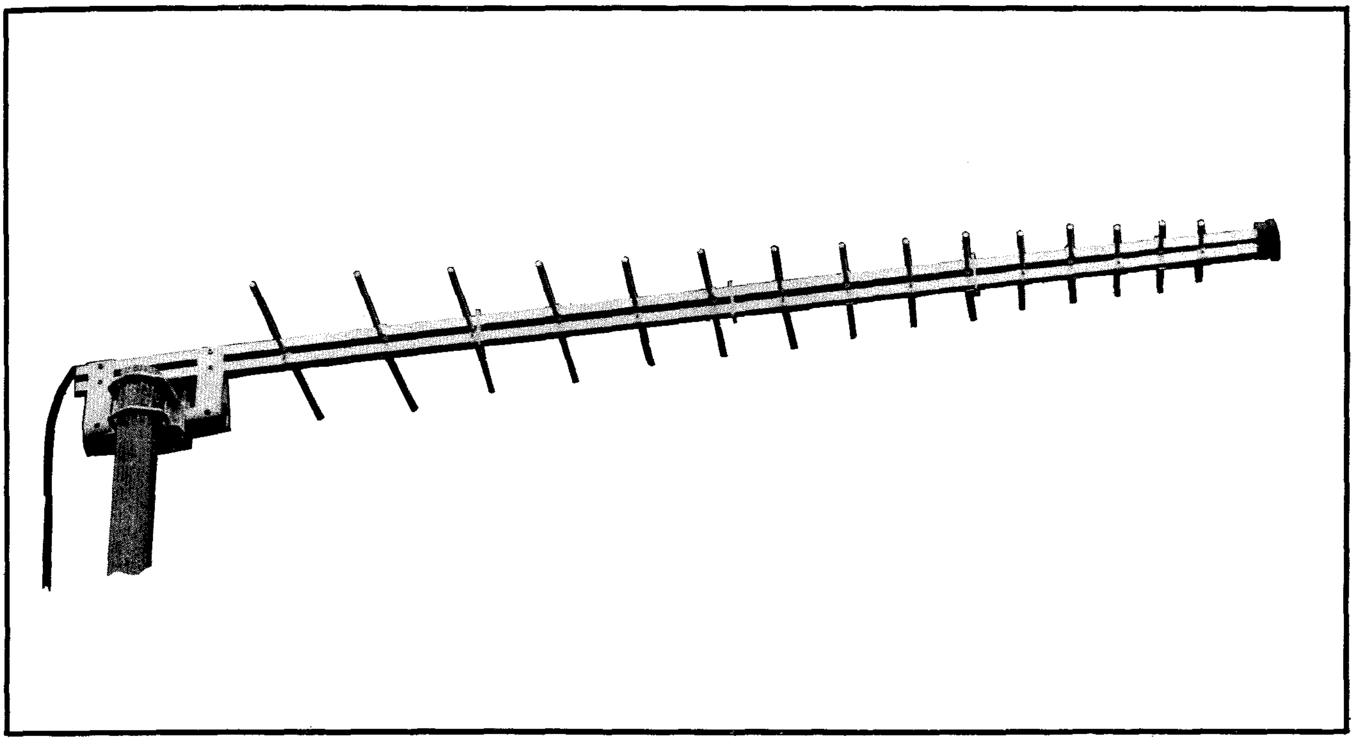

Fig. 3 - Log-periodic aerial with standard mount

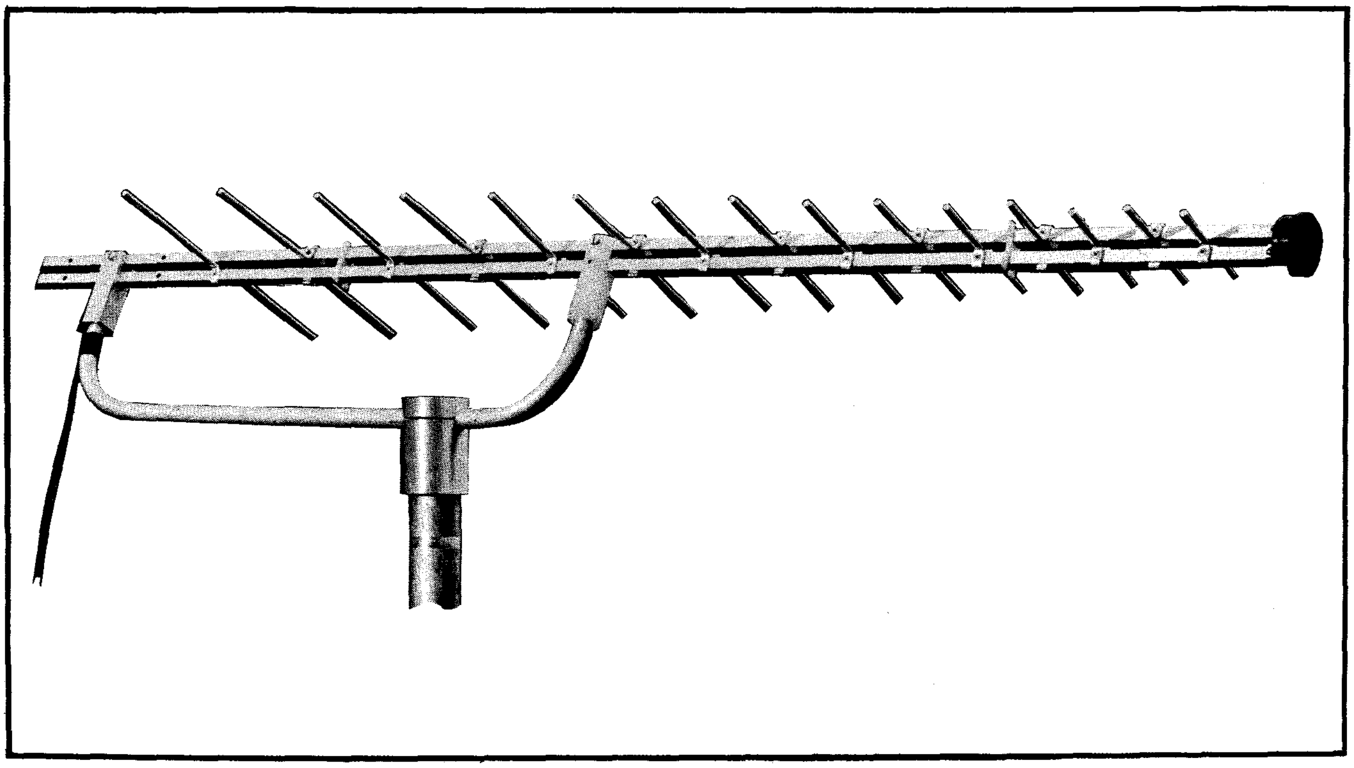

Fig. 4 - Log-periodic aerial with special mount
(Horizontal polarization only)

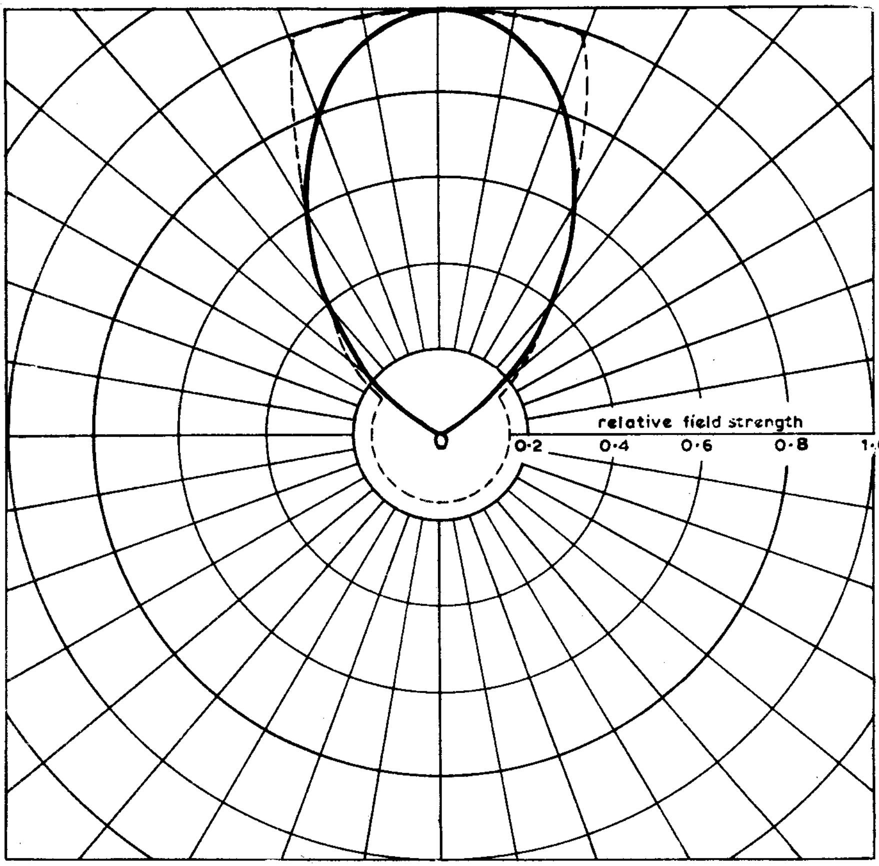

Fig. 5

E-plane radiation pattern 650 MHz

--------- CCIR templet

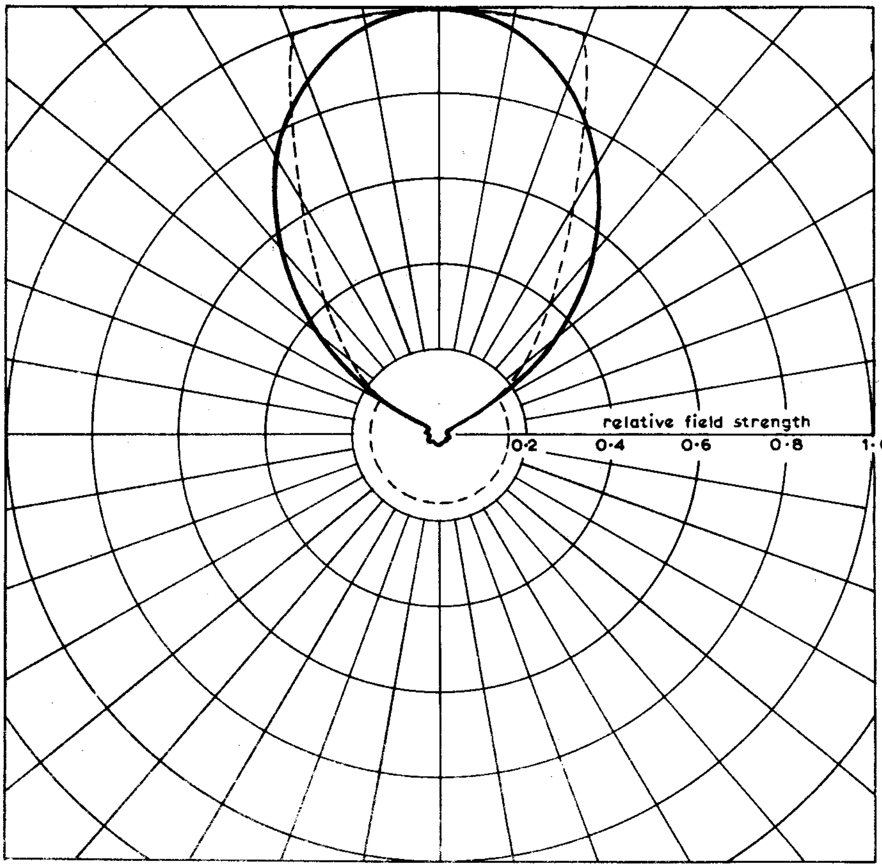

Fig. 6

H-plane radiation pattern 650 MHz

-------- CCIR templet

TABLE 1

Frequency MHz	Half power beamwidth degrees		gain dB rel. $\lambda/2$ dipole	Minor lobes dB below maximum field	
	E-plane	H-plane		E-plane	H-plane
450	± 27°	± 34°	8·6	26·7	23·5
500	± 26°	± 32°	9·3	33·2	33·6
550	± 26°	± 33°	8·9	30·0	25·6
600	± 26°	± 32°	9·2	34·4	31·5
650	± 26°	± 32°	8·9	30·2	30·0
700	± 27°	± 34°	8·7	27·0	25·0
750	± 27°	± 35°	8·4	25·0	25·5
800	± 26°	± 33°	9·0	35·5	24·0
850	± 26°	± 33°	8·7	26·0	24·0

4. MEASURED PERFORMANCE

Measured horizontal radiation patterns are shown in Figs. 5 (E-plane, horizontal polarization) and 6 (H-plane, vertical polarization). Although these patterns were measured at 650 MHz they are typical of patterns at any frequency in Band IV or V. Table 1 summarizes the pattern performance of the aerial over its entire frequency range.

Fig. 7 shows a typical v.s.w.r. characteristic referred to a 71 ohm connector cable.

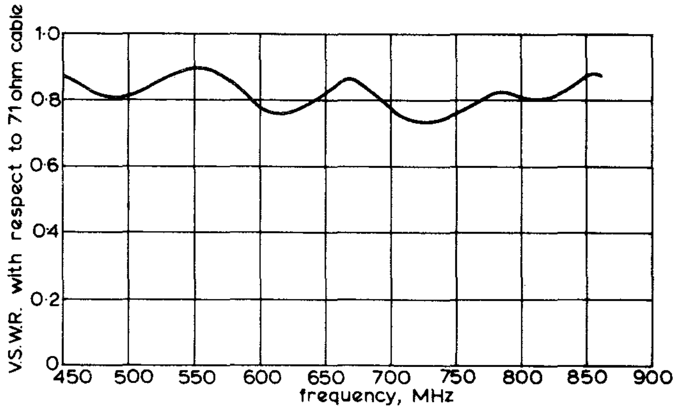

Fig. 7 - Typical V.S.W.R.

5. DISCUSSION

The C.C.I.R. templet for the recommended minimum directivity of u.h.f. receiving aerials is superimposed on the radiation patterns of the aerial in Figs. 5 and 6. It will be seen that the E-plane pattern (horizontal polarization) meets this templet although there is some transgression in the case of the H-plane pattern (vertical polarization). The aerial would therefore always be suitable for the reception of horizontally polarized transmissions, providing the gain is adequate. In general terms it will be satisfactory at locations having received field strengths in excess of 70 dB (rel. 1 μV/m). In situations where the received transmission is horizontally polarized but where the gain is marginal, the use of an aerial pre-amplifier could be considered, as the benefits of the very low back and side lobes would thereby be preserved. For the reception of vertically polarized transmissions the radiation pattern could be improved by employing two aerials stacked side by side. However, in many situations where the transmission is vertically polarized, but where the advantages of low back and side lobes are needed, it is likely that the small transgression of the C.C.I.R. templet will not be serious. The performance of the aerial, as described, indicates that the principal advantages claimed for the log-periodic form have been achieved; viz,

(a) low back and side lobes

and (b) constancy of performance over all the u.h.f. television channels at present in use in the U.K.

The C.C.I.R. templet is used as a criterion for planning purposes but greater rejection of signals from the back and side of the aerial than that implied by the templet is necessary in certain areas to combat ghosting. (Available receiving aerials largely meet the C.C.I.R. templet, although there may be transgressions at the extremes of the specified frequency bands.) There would appear to be a good case for the introduction of an aerial of the type described in this report to the range of u.h.f. receiving aerials available to the public.

6. REFERENCES

1. CARREL, R. 1961. The design of log-periodic dipole antennas. *I.R.E. int. Conv. Rec.*, 1961, **9**, 1, pp. 61–75.
2. C.C.I.R. Recommendation 419, Documents of the XIth Plenary Assembly, Oslo 1966, Vol. V, p.62.

JMP

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